

Cryogenic Facility for Mucool at Linac

MUCOOL – MICE meeting

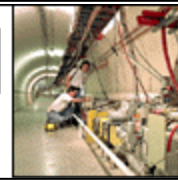
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Engineers: Arkadiy Klebaner, Alex Martinez, Christine Darve....Del Allspach from PPD(Hydrogen expertise)





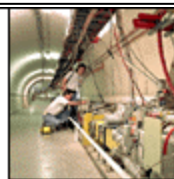
Description of Helium and Hydrogen Systems

- ☾★ Helium System
 - ☾★ Layout
 - ☾★ Review of Test at 20K
 - ☾★ Future Solenoid Setup
- ☾★ Basic Overview of Helium to Hydrogen Heat Exchange
- ☾★ Controls and Instrumentation Issues
- ☾★ Helium and Hydrogen Safety Issues
- ☾★ Approximate Schedule for Completing Facilities
 - ☾★ Present status

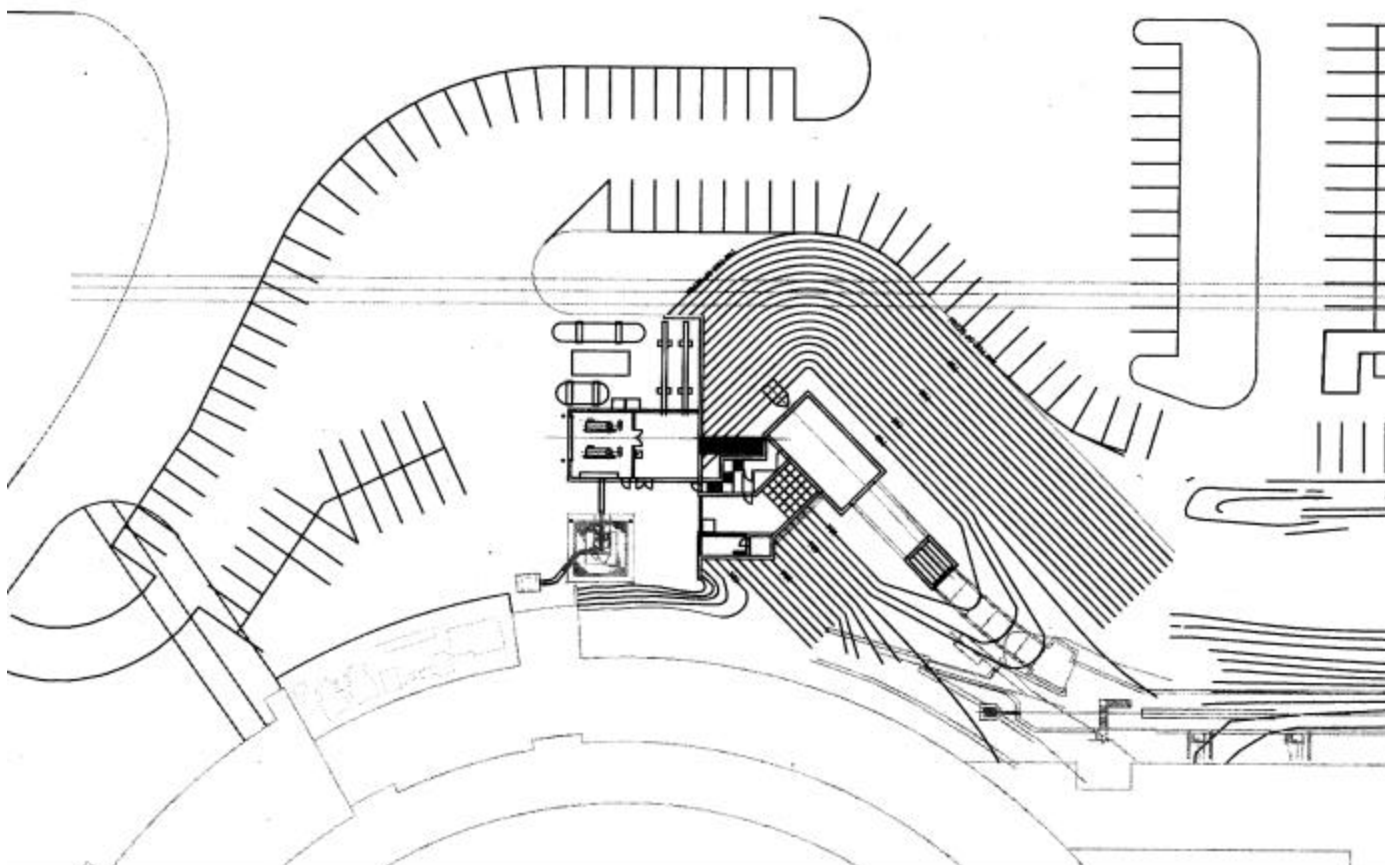


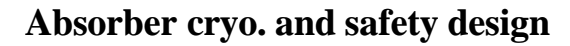
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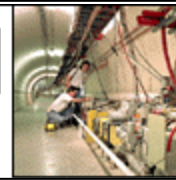
Absorber cryo. and safety design





The site plan illustrates the layout of the Experimental Hall and its surrounding infrastructure. Key features include:

- Storage and Gas Areas:** Helium Storage, Helium Gas Trailer, and Liquid Nitrogen Storage are located in the upper left section.
- Refrigeration and Compressor Rooms:** A Refrigeration Room (Floor EL. 746'-6") and a Compressor Room are situated in the center-left.
- Structural Details:** The plan shows various structural elements such as walls, doors, and stairs, along with dimensions for room sizes and clearances.
- External Features:** A Fence, a Lift, and a Hydrogen Manifold Room (Enclosed) are shown in the lower right area.
- Topography and Orientation:** Contour lines indicate the terrain, and an arrow points towards the North.



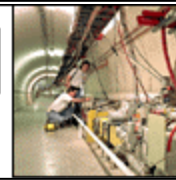
Helium Plant Hardware

Compressor Room

- Two 400 hp, oil flooded screw compressors...
- Oil removal skid system
- Motor control centers for Remote Operation

Refrigerator Room

- Tevatron satellite refrigerator used normally for <5 K operation (to be operated at 15K output)
- Includes expansion engine(s) for appropriate demand
- Transfer line connection to Experimental hall which includes 5K, 20K, 80K circuits



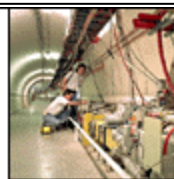
Helium Plant Hardware (continued)

Future 5K (Helium) Needs

- **Must Have 5K supply for Superconducting Solenoid magnet - don't want to**
- **use same refrigerator as 20K system**
- **Options: Consider 2nd Tevatron satellite refrigerator or smaller CTI unit**

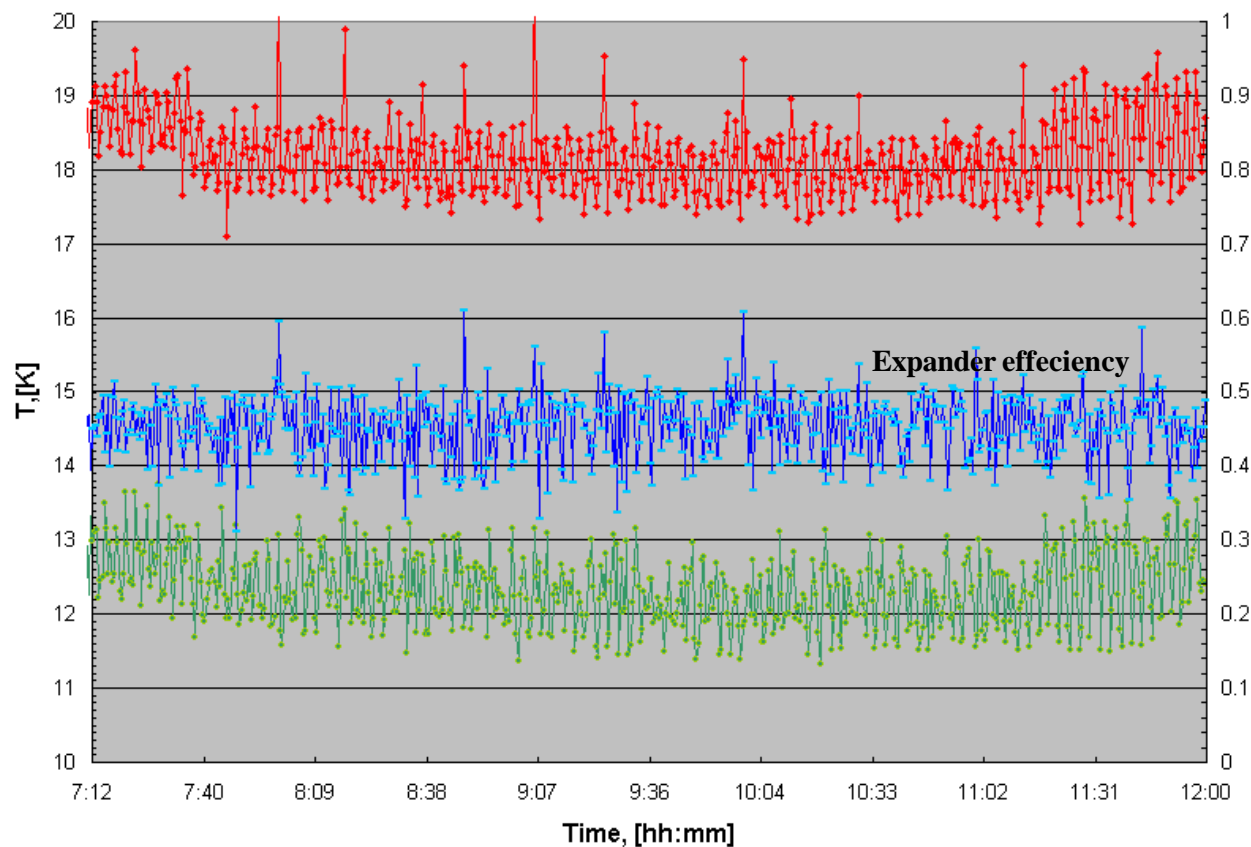
Components Outside of Building

- **LN2 Horizontal dewar for pre-cooling of Heat exchanger and 80K shield needs**
- **Helium Gas storage**
- **Capability to Purify Helium gas with Mobile purifiers used in Tevatron cryogenics**
- **Transfer line and gas headers connecting Refrigerator room and experimental hall**

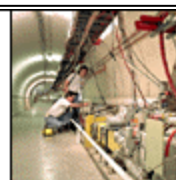


Testing Stability of Helium System at 15-20 Kelvin Operation

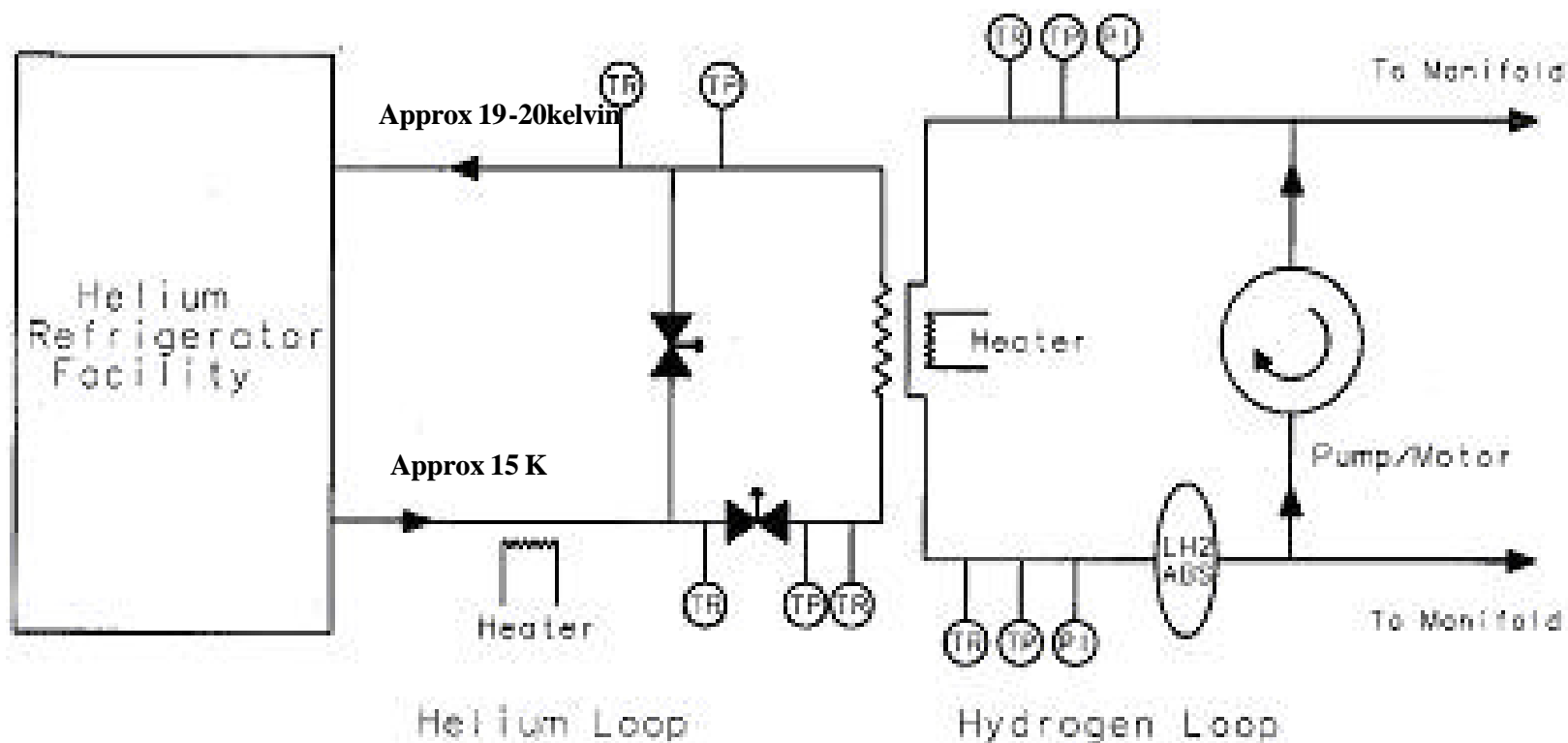
MuCool Test at F4

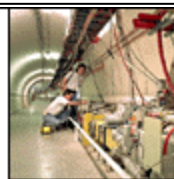


η_s , [W/W] Stability of Refrigerator
Operating at approx. 15
Kelvin output



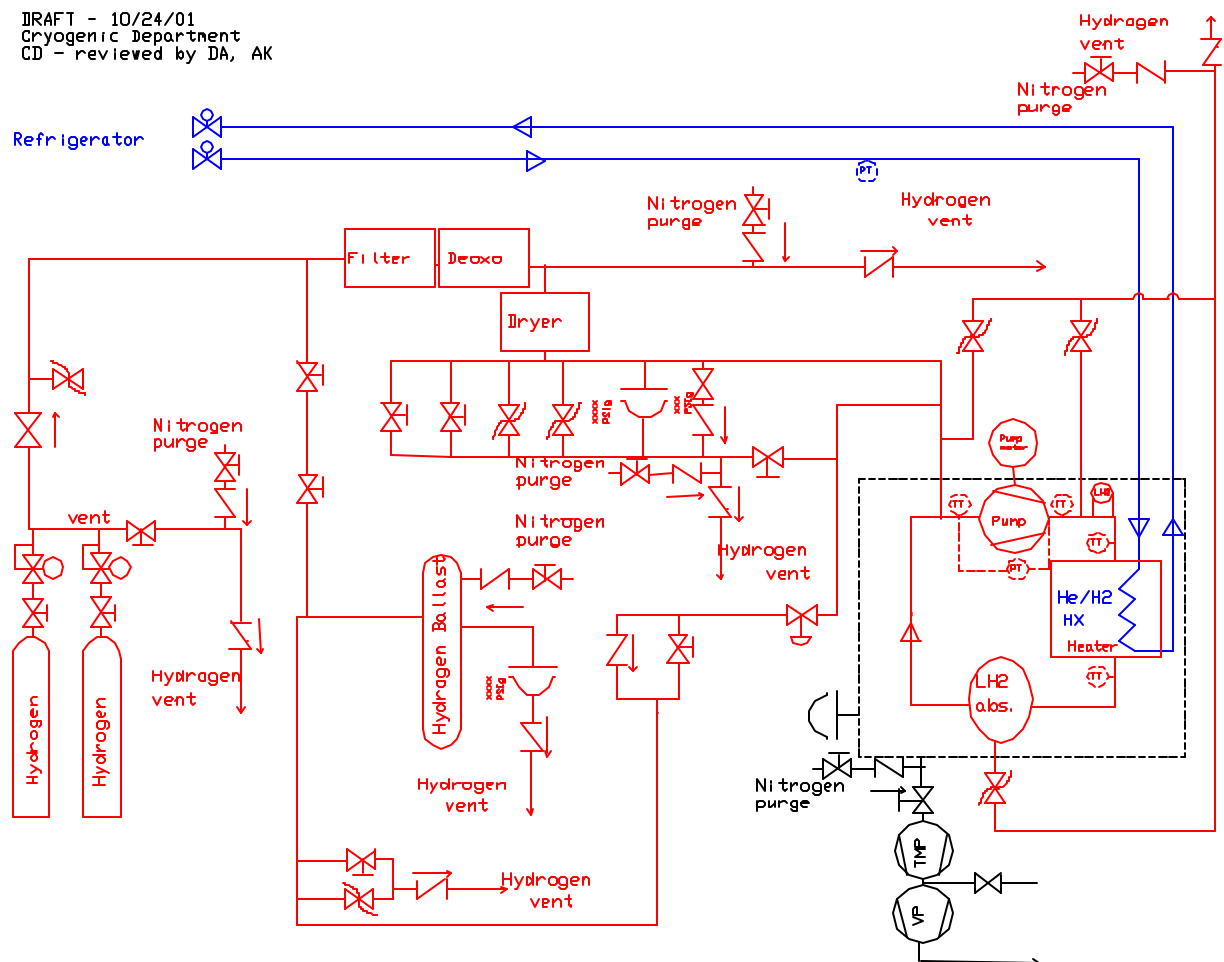
Basic Layout of Cryo Cooling for Hydrogen





Hydrogen Loop including Manifold System (SLAC-style)

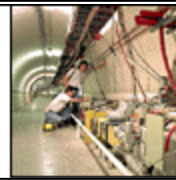
IRRAFT - 10/24/01
Cryogenic Department
CD - reviewed by DA, AK





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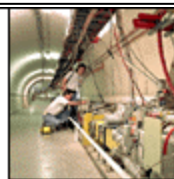


Absorber cryo. and safety design

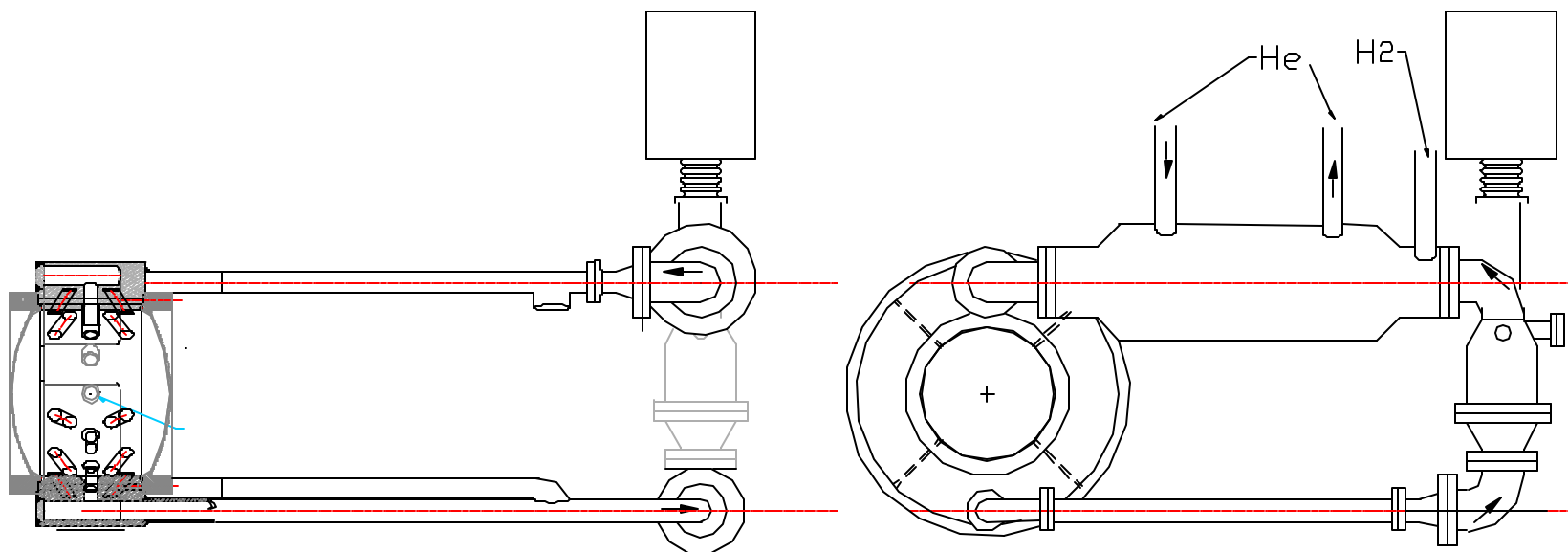
Liquid Hydrogen Absorber system

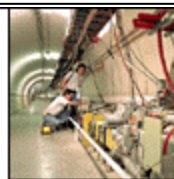
Components:

- ☾ Cryostat
- ☾ Absorber
- ☾ LH2pump
- ☾ Helium/Hydrogen heat exchanger
- ☾ Hydrogen loop piping
- ☾ "Dedicated" Safety PLC for Process Controls and Interlock Mechanisms



Pressure drop localisation





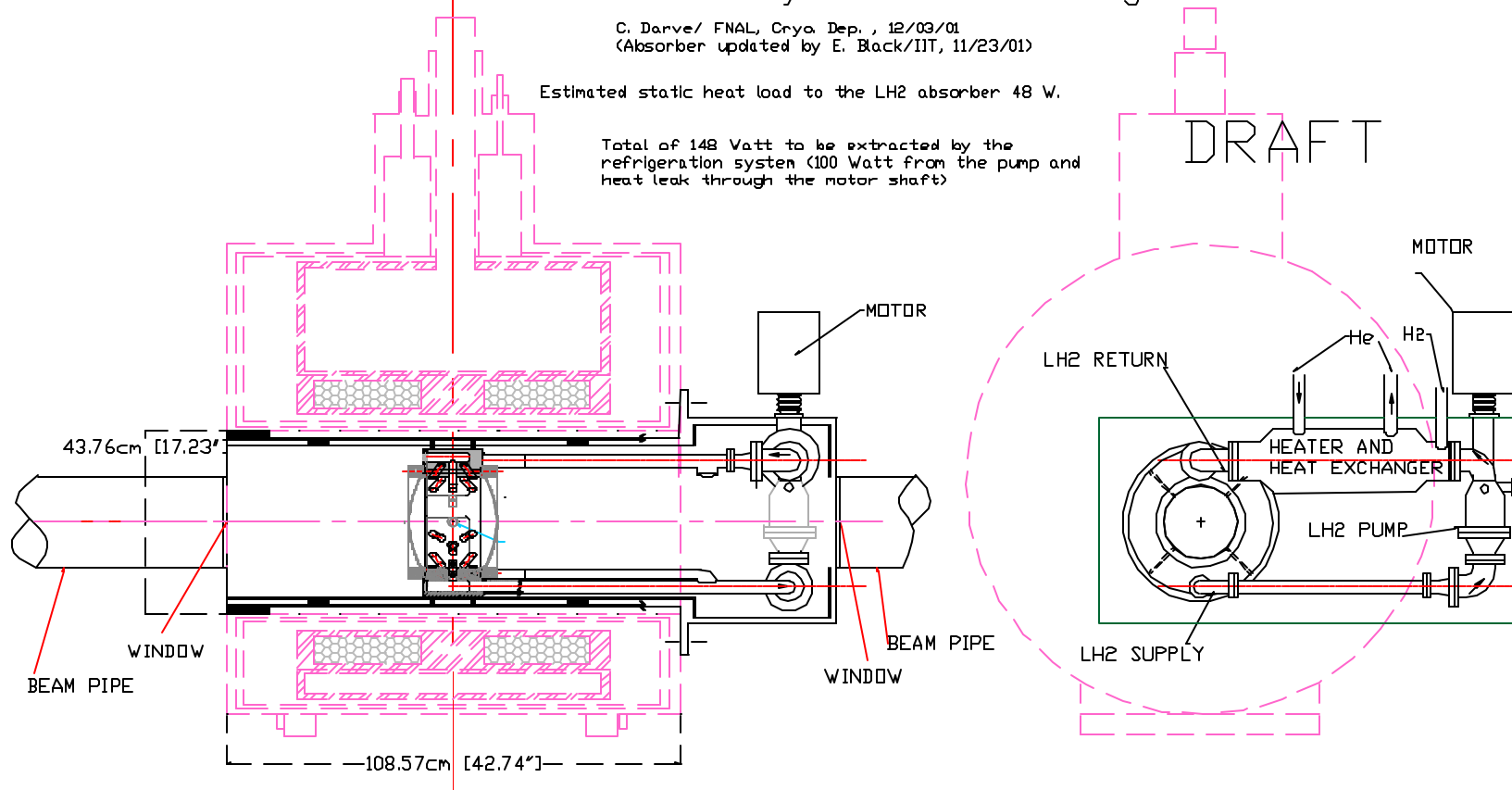
Liquid Hydrogen Absorber system

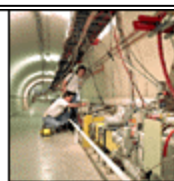
Draft for the Absorber assembly in the G-Lab magnet

C. Darve/ FNAL, Cryo. Dep., 12/03/01
(Absorber updated by E. Black/IIT, 11/23/01)

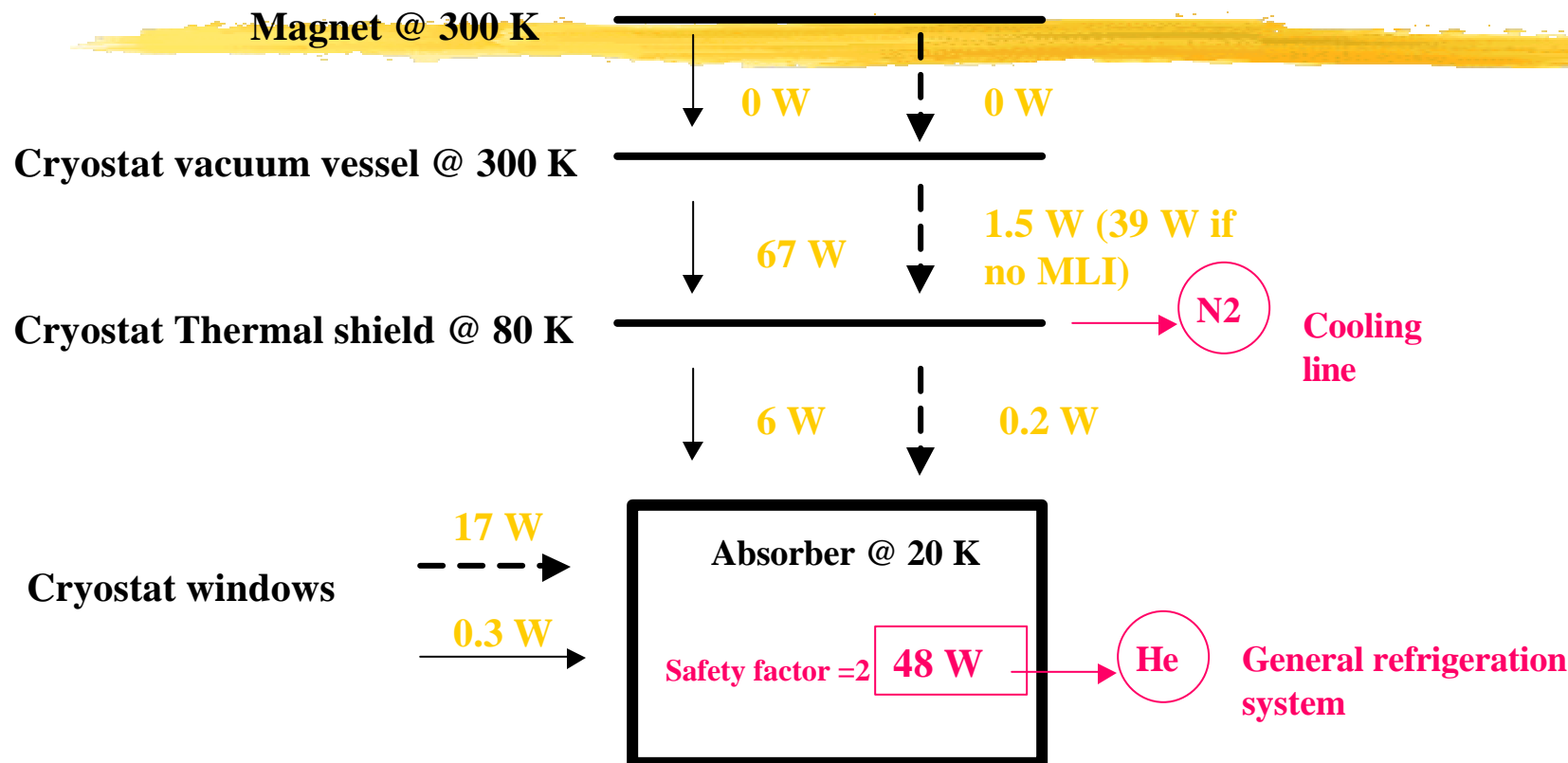
Estimated static heat load to the LH2 absorber 48 W.

Total of 148 Watt to be extracted by the refrigeration system (100 Watt from the pump and heat leak through the motor shaft)

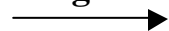




Heat load from ambient to absorber temperature level



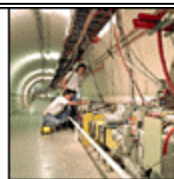
Legend:



Heat transfer by conduction through the G10 support



Heat transfer by radiation and through MLI

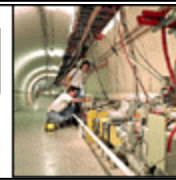


Hydrogen System Stability Issues

- The total load (beam load plus static loads) upon the hydrogen is desired to be kept as stable and steady as possible.

Under conditions where the beam goes off the loading on the hydrogen cryogenics will change proportionally and we can have, at a minimum, instabilities that are undesirable. The worst case is we go too cold and freeze hydrogen (14K freeze point).

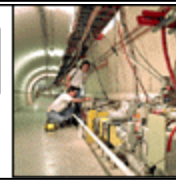
Thus, we would like to use a heater that actively compensates for beam current changes. At SLAC, the beam current was measured and fed into an approximating beam power program whose output eventually made step changes in the hydrogen heater power.



Hydrogen System Stability Issues (cont.)

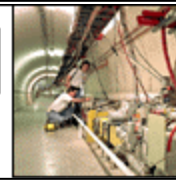
· The proposed pump requires a 1 hp drive and will need to be interfaced to a Variable Speed Motor and appropriate drive. There are some safety issues related to the purchase of this motor and drive that we still must understand. SLAC simply “floods” the motor case with pure hydrogen so that they avoid any explosion mixture of hydrogen and oxygen.

Furthermore, we will need to understand a strategy to control the pump speed that determines directly the total flow within the hydrogen loop. I envision a fairly fixed speed under steady state operations with minor changes as loads vary. In reality we will probably measure pressure head instead of flow to determine proper speed settings.



Hydrogen System Stability Issues (cont.)

- We need to “fire” the fast acting solenoid ball valves reliably to prevent rupture discs from rupturing unnecessarily. (10-15msec action time)



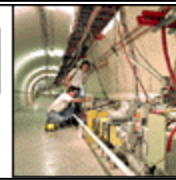
Hydrogen Safety Concerns

- **Everywhere there is hydrogen present we must install hazardous gas detection modules. There will be a number of these in the Experimental hall and manifold room, while possibly having others in some non-obvious locations (ex: helium refrigeration room since pipes connect and helium building is elevated above hydrogen).**
- **Hydrogen gas detection sensors will need to be configured such that any detection of hazardous gas causes all the electrical power to these areas to be turned-off. Power supplies to magnets, to cryogenic heaters, etc must be de-energized to eliminate any explosion hazard.**
- **Further, the Cryogenics group plans on designing this system so that any electrical device (cables, connectors, starters) is compatible with the “Special Occupancy” chapter within the NEC Electrical Code. We realize it may not be possible to make the Experimental Hall fully code worthy but the cryogenics will be done this way due to its proximity to the hydrogen source.**



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First Thoughts On Hydrogen Controls---Safety PLC

QUADLOG®: The Safety PLC (Siemens-Moore)

The QUADLOG system delivers safer, more cost-effective solutions than traditional PLC technologies. Additional hardware and engineering are not required. Maximum safety and reliability provided. Third-party organizations recognizing QUADLOG:

TUV approval to level AK6

IEC 61508 compliance

CE mark

FM approval for Class 1, Div. 2 hazardous locations

CSA approval for Class 1, Div.2 hazardous locations

ABS type approval

Includes Control Loops for Process Controls, Ladder logic, other tools...